Two Addresses

TO THE

ENGINEERING STUDENTS

OF THE

UNIVERSITY of BARCELONA

ALTGELD HALL STACKS

BY

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PREFACE.

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The occasion of the writing of these two addresses occurred as follows:

About the middle of April, 1922, during a trip around the world by my wife and myself, we arrived at Barcelona, Spain; and, when there, I was invited to address the engineering students of the University. I first read to them in French a short address entitled *"La Vie de l'Ingénieur Civil"* that I had prepared some six months previously and delivered to the students of a technical school at Shanghai, China; then, from a short list of headings, I gave the first of the two following lectures, my discourse being translated, a sentence at a time, into Spanish. As the Faculty and students were pleased with my efforts, I delivered two days later in the same manner the second address.

My hearers appeared to take a deep interest in all I told them, and asked many questions not only about the subjects treated but also concerning American engineering practice; and, upon the conclusion of my second talk, I was earnestly urged to put the entire discourse into writing, so that it might be translated into Spanish and published in one of the technical periodicals of Barcelona. To this I agreed; and a week or two later, when we were in Madrid, I kept my promise, so that before leaving Spain I was able to send on the hand-written paper.

Whilst we were in Madrid, I was requested to repeat these lectures and the before-mentioned French address to the engineering students in the University of that city; and, of course, I complied. On that occasion it took three instead of two meetings to complete the said lectures, partly because my three interpreters in Madrid were not as expert as the gentleman who had done me the honor in Barcelona to translate all five of the lectures that I gave there during the week of our sojourn in that city, and partly because of the intense desire of the young men to learn about American engineering and student life in the U. S. A.

Upon the conclusion of the last lecture I was again requested to put my discourse into writing for translation, and to give it to the

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Madrid students for publication in their official organ; but I had to refer them to my friends in Barcelona, who, I assured them, would publish the lectures and provide them with copies thereof.

Just as we were leaving Madrid I received a telegram from Paris asking me to address the students of a large technical school there; and I complied by giving them the same disquisition during a session that, by special request of the audience, was extended to two hours, so as to cover the entire ground of the two lectures; but this time the Shanghai address was omitted.

Upon the completion of my talk, the Director of the Institution urged me to put into writing what I had told the students, so that it might be translated into French and circulated among several thousand young men who were taking a correspondence course under the auspices of the said Institution. I explained that I had already done this, but that the MS. was then in Barcelona; and thereupon I arranged to have it sent to my good friend and business representative in France, Captain Jacques Rabut, C. E., for translation into French.

The Spanish translation, made by another good friend of mine, Señor Sixto Ocampo, C. E., has already been published in full in "Técnica"; and by this time the French translation has probably appeared—possibly in a somewhat reduced form.

After the original MS. was delivered to my New York office, it was transcribed by type-writer; and, according to a previous promise, a copy was sent to "The Polytechnic," the students' official organ at the Rensselaer Polytechnic Institute, the editor of which paper, I have learned, is going to condense it for publication.

Those of my friends in this country who have read the MS. say that the lectures ought to be published in full and made available for the engineering students of North America; consequently I have decided to have them printed in pamphlet form and distributed with my compliments among the professors of engineering for the use of their classes.

It is my earnest hope that many young men who read it will be truly benefited by its perusal.

J. A. L. Waddell,
Consulting Engineer.

New York City,

November 7th, 1922.

INTRODUCTION

Gentlemen:

The preceding discourse, which I have given you in French, is the formal address that I agreed to deliver; and now, with your kind permission, I shall offer you some friendly advice in relation to your life at the University and how to make the most of your opportunities therein. That will conclude what I have to say today, excepting that, before we adjourn, I shall be pleased to answer, if I can, any questions propounded concerning American engineering practice in general and my specialty of bridgework in particular.

Then, if my discourse pleases you, on the day after tomorrow at noon I shall be glad to give you a similar lecture of advice upon how best to succeed in engineering practice after graduation. In that event I might find it necessary to treat further some of the ideas advanced today, thus, perhaps, involving a slight repetition. If such be the case, I trust you will pardon me; for I promise that I shall endeavor to reduce all such redundancy to an absolute minimum.

The giving of advice to young men is often just about as efficacious, as pouring water on a duck's back. Especially true is this in the case of professors talking to their students or parents to their sons; nevertheless I have found many times in my long career that some of the advice I have given has borne fruit, thus proving that engineering students do really listen to and heed, more or less, the exhortations of old and successful practitioners in the profession.

For four decades I have been lecturing in the universities, colleges, and technical schools of the United States, Canada, Japan, and China, always, by the way, without any financial compensation, believing that it is the bounden duty of every successful engineer to aid in every practicable manner the young men who are to follow him in the profession. In all, I have thus visited more than fifty institutions of learning, and some of them several times, besides lecturing to many engineering societies, both national and local.

Very often men come to me and state that something I have told them in my lectures or that they have read in my books has been of great assistance in their careers—and this is ample compensation for my long-continued efforts to be of service to my brother engineers, to raise the standing of the engineering profession to a higher plane, and to increase its usefulness to humanity.

PART I

ADVICE CONCERNING LIFE AS AN UNDERGRADUATE.

EARNESTNESS OF PURPOSE.

A prime essential for success, not only in college but also throughout life, is the development of earnestness of purpose. Without this attribute no one can be truly successful. Remember the old adage, constantly drilled into me by my good mother when I was a child, "Whatever is worth doing at all is worth doing well." If you always aim to apply this principle, you will be surprised to see how efficient you will soon become.

COLLEGE ACTIVITIES.

Some unthinking persons occasionally state that the time spent by students in college activities is totally wasted. Far from it! Within reasonable limits, such activities are decidedly beneficial, in that they afford a certain kind of character-development that will be useful afterwards. Moreover, they create acquaintances that often endure through life; and many times these prove to be of benefit both socially and financially. It is mainly through friendship that big business is done; for, other things being equal, one would rather deal with a man whom he knows and likes than with a stranger. I have often stated that, in my opinion, one-half of the benefit obtained at college comes from outside of the class-room; and many thinking men have agreed with the statement.

Some college sports, it is true, involve a waste of time—those in which a few individuals work strenuously and the rest look on admiringly and applaud, such as foot-ball or base-ball; but those in which all can join, such as tennis, hand-ball, la pelota, paper-chase, or basket-ball, are useful in providing much-needed physical exercise, as well as in developing a desirable college spirit.

Again, college politics are a good training for the real politics of after life; and such training is a valuable asset.

TRUTHFULNESS.

A reputation for strict truthfulness is beyond price. There is never any sound reason for the telling of a lie! A chronic liar is utterly despised by his fellows, who soon form the habit of avoiding him; and the man whose word cannot be depended upon is incapable of inspiring respect in his associates.

LOYALTY.

Throughout life loyalty is a characteristic that is both admired and appreciated. It ranks with truthfulness in a man's make-up. College is a good place in which to develop this desideratum, for a student should be loyal to his *alma mater,* to his class, to his fra-

ternity, to his professors, to his parents, who are providing the means for his education, and lastly to himself by leading a clean and wholesome life.

AIDING OTHERS.

Every college student should endeavor to aid his fellows in every practicable manner. Those of superior intelligence and ability should help in their studies those who are less fortunate in natural endowments, but not to the extent of making them mentally lazy by doing all their thinking for them. There are many other effective ways of rendering assistance, such as a friendly loan of money when needed, offering a word of warning when a fellow-student is starting on the downward path, lending one's possessions to those not so well provided with worldly goods, and sympathy for those in grief or trouble.

Such altruism will by no means go unrewarded; because generosity is always admired, and because it invariably develops affection for its possessor amongst those with whom he is well acquainted and whose good-will and friendship he should value. Again, one never in any way learns to understand a thing so thoroughly as he does by teaching it to others; for, in order to explain it, he must understand it clearly in every particular. Hence, if a student makes a practice of explaining difficult problems to his class-mates and the under-classmen, he will have a far better understanding of the course than he could obtain by studying in the ordinary manner.

LEARNING ONE'S MOTHER TONGUE.

Every student of engineering should spend considerable time in the study of his own language, so as to be able to read, write, and speak it with ease and vigor. If there are optional courses given in it, he should take them; and his study of this important branch of learning should extend over the entire five years of the engineering curriculum.

If there be given a course in oratory, he should certainly take it; and he should join the debating societies and assume an active part in their functions. The ability to speak well when on one's feet, without previous notice, is, unfortunately, a rare accomplishment among engineers—at least this is true in America.

There is a general opinion amongst engineering students that the study of one's own language is not of great importance, as compared with that of mathematics and technics; but, believe me when I tell you that this idea is fundamentally and absolutely wrong. To become a successful engineer, one must be capable of persuading others concerning his ability to do contemplated work; he must be able to draft his specifications and contracts with clearness; and his reports need to

be not only plain, sound, and convincing, but also pleasing, and even elegant, in diction.

In order to augment his technical vocabulary and to understand what he reads and hears about various lines of engineering, an undergraduate should study glossaries of technical terms, especially those having illustrations, so that he may recognize, when he sees them, the different parts of structures and machines. In relation to bridgework you will find at the end of my treatise on "Bridge Engineering" a glossary containing several thousand definitions of technical terms used in the theory and practice of the design and construction of bridges; but, unfortunately, it is not illustrated. It should be the duty of the professors of engineering in all lines to prepare illustrated glossaries of technical terms, so as to enable their students to obtain at least a smattering of practical knowledge concerning engineering constructions. It is true that the study of glossaries is very dry work, therefore it may have to be considered as a dose of medicine requisite for one's technical well-being.

THOROUGHNESS.

The development of a habit of thoroughness is an important step in the preparation of oneself for his life's work. Without the ability to do everything thoroughly one cannot make much of a success in any kind of career, hence the student should be continually on the watch to prevent himself from falling into loose habits and from doing things in any way but the very best practicable.

EXACTNESS.

What I have just said about thoroughness applies also to exactness. Too many students, when solving examples that are given to illustrate the theory they have studied, are prone to content themselves with approximately correct results, and are unwilling to go over and correct calculations the findings of which they know to be wrong. Their plea for so doing is that they have not the necessary time, and that the faulty calculations they have made will suffice to teach them the method. This is bad reasoning, because such a practice would soon lead to an inability to do any figuring correctly. In engineering practice all calculations have to be carefully checked—often more than once—and generally by an independent computer, so that all the mistakes that have been made may be corrected before the calculations are utilized for actual design, estimate, or construction. You see, therefore, how important it is to be truly accurate in all your figuring.

Accuracy, however, can be carried to extremes; and sometimes it is so carried by engineers who ought to know better. For instance, in estimates of cost one should never run the final products out to decimals of dollars. In very small constructions the nearest ten

dollars is sufficiently accurate for all practical purposes; while, in those of fairly large size, the nearest one hundred dollars will suffice. In many very large projects on which I figure I carry out the products only to the nearest thousand dollars. A meticulous accuracy in making estimates is an indication of a mind of rather inferior ability—unable to grasp great problems and solve them in a truly practical manner.

NEATNESS.

A habit of neatness in all that one does is a wonderfully valuable asset to an engineer, especially in producing a happy effect upon the lay mind; hence it should be developed as much as possible during one's technical course.

SYSTEMIZATION.

Quoting from my old book, "De Pontibus," written a quarter of a century ago, Principle III in the chapter on "First Principles of Bridge Designing" reads thus:

"The Systemization of All That One Does in Connection with His Professional Work Is One of the Most Important Steps That Can Be Taken Toward the Attainment of Success."

The years that have ensued since that was written have given conclusive evidence of the correctness of the statement; consequently you may take my word for it that the man who is systematic in all he does is sure to be more successful in life than those of equal ability who are not, and that the possession of the attribute of systemization will often compensate for a certain amount of deficiency in mental capacity.

CONCENTRATION.

It is advisable for an engineering student to develop the faculty of concentration, for instance, by teaching himself to study when surrounded by his companions who are talking and amusing themselves. It is truly a difficult matter, but in time it can be accomplished.

As an example of it, I might state that, when sitting at my office desk engaged in some difficult and intricate investigation or in writing some important report or memoir, anyone can enter the room and break in abruptly upon my line of thought for some time; and, after I have finished talking with him, before he reaches the door I can resume my interrupted contemplation and take up the broken thread of my work. This ability to react quickly is the result of long practice, and has been developed by sheer necessity. It is truly a time-saver, and hence of real value.

CLEAR THINKING.

What is meant exactly by the term "clear thinking" may be somewhat difficult to define, nevertheless the attribute is very real

and truly valuable. To develop it requires time, effort, and practice. My good friend, Dr. George F. Swain, an eminent American engineer, has issued a short monograph on the subject; and I recommend that each of you read it and follow the suggestions made by its distinguished writer.

OUTSIDE READING.

Some students find that it requires practically all of their time to keep up their studies and to take the amount of exercise necessary for the proper maintenance of their health; but most students have some spare hours. However, many of these are wasted in idleness—or worse. Such men should take up and pursue regularly a course of reading, both technical and literary. An hour or two per day spent in this manner will enhance one's knowledge, give him new viewpoints, and broaden his vision; hence I earnestly urge that you adopt this suggestion. In laying out such a course of reading, consult the faculty of your institution, and, if practicable, also some engineers of age and standing, and be guided by their counsel.

There is a book of my editing, entitled "Addresses to Engineering Students," that I advise each of you to read—at least those of you who possess a reading knowledge of English—for it is full of good advice from many prominent engineers and professors of engineering. I have ordered that three complimentary copies of the work be sent to the library of your university for this purpose. Read a little of it at a time, lest its perusal become tiresome; but pick it up whenever you have a half hour to spare and absorb at least one address. You will probably become so interested in its contents that you will ultimately read some of the addresses several times.

In order to convince you of the importance of this book, I might state that the French government had one of its brilliant young engineers, Captain André Rabut, who was killed at the beginning of the war when gallantly leading a charge on the enemy, translate it for official publication and distribution amongst the engineering instructors in the technical schools of France.

And now, gentlemen, I believe I have offered you enough advice for one sitting. If, as before mentioned, its character pleases you, I shall be glad on the day after tomorrow to give you a further discourse on the same subject, but with special reference to your engineering practice after graduation.

PART II

ADVICE CONCERNING LIFE AFTER GRADUATION.

EXPERIENCE versus SALARY.

As an engineering student approaches the day of graduation, there is generally in his mind one absorbing thought, viz., "what kind of position shall I be able to secure, and what will be the salary?" Upon the solution of this question an engineer's future is sometimes dependent; but, fortunately, not always, because a man of good judgment, when he finds himself doing work that does not interest him or that does not hold out much promise for the future, can always make a change of occupation.

In selecting a position, if there be a choice (as there is when times are good), the wise man will take the one that promises to give him the best experience, and not that with the greatest financial compensation. Generally it will be found that the best positions in respect to experience carry with them the smallest salaries. This is as it should be; because, if one is given work which his scholastic training fits him to do immediately fairly well, he should receive adequate compensation for his labor—as much as is paid others for doing the same work with approximately equal efficiency. On the other hand, if the work be difficult and require practical experience, the salary should be small, if not absolutely zero; because not only does the employer fail to make money out of the novice's efforts but often he loses it by having to devote some of the time of expensive assistants to teaching the newcomer his duties.

My recommendation is always to choose the difficult task with the small salary; and to take it, even if, for a few months, there be no pay at all.

Here is a bit of advice that I gave the graduating class of the Engineering Department of the University of Kansas as long ago as 1894; and I now offer it to you. If a young engineer desire ultimately to attain great success and eminence in the profession and can afford to live very simply for a few years, let him choose at the outset a minor position in some line of engineering at small pay and keep it only so long as he feels that he is obtaining valuable experience. Then, after he has "learned the ropes," let him take another subordinate position in some other line and do as before; and let him continue this procedure for five or six years.

Of course, as his general practical knowledge increases, his services become more valuable, and naturally his salary will be augmented,

but he should never let the question of compensation prevent his accepting a position that promises to afford truly valuable experience. During this novitiate he should decide as to the line of engineering he would prefer to adopt for his life's work; and, thereafter, the positions he elects to fill should be chosen with a view to obtaining good experience for that line.

Don't begin to specialize too soon. There are two good reasons for this—first, a specialist who is trained in one line only will necessarily become narrow in his views and a man of one idea; and, second, the general public has but little confidence in a very young specialist. I began my independent practice as a bridge specialist at the age of thirty-three—and that certainly is young enough. Remember that you must learn in any line of engineering what others already have learned, before you can assume the responsibility of designing and carrying out great works, especially those involving more or less unprecedented conditions.

I have seen this method of obtaining wide general experience tried with great success; but it requires courage to attempt it and to carry it to a conclusion. I recognize the fact that it is rather galling for a young engineer, when working for small pay, to see his classmates receiving better compensation because of their having settled down to steady jobs; nevertheless he will eventually overtake and pass them in the race for prominence in the engineering world, with its usual attendant compensation.

FAITHFULNESS AND LOYALTY.

An engineer should be ever faithful in his work. It should always take precedence over everything else that interests him; and he should never neglect to push it to successful conclusion in the shortest practicable time. Don't be afraid of working yourself out of a job; for there are plenty of others to be obtained; and the more quickly you finish one the sooner will you be able to undertake another, thus augmenting your practical experience.

At all times be loyal to the person or company for whom you work. If you cannot approve of their method of doing business, do not complain to others about it, but indicate your objections to your principals. Then, if they do not make a change that satisfies you, leave them and seek occupation elsewhere.

TIME-SERVING.

Do not be a time-server or work by the clock, following the example of the navvy who, having raised his pick, drops it before delivering the blow when he hears the signal announcing quitting time. Do not arrive late on your work and spend a quarter of an hour getting ready to settle down to business. If it takes you that long

to arrange your thoughts and apparatus, come enough earlier to give your employer full time.

Again, do not begin to get ready to quit until the closing hour has actually arrived; but spend a little of your own time in arranging your papers and apparatus for the night. Most employees are time-servers; and, consequently, they remain employees at small pay instead of becoming either principals or highly-valued assistants.

LOVE OF WORK.

Learn really and truly to love your work. Unless it become to you intensely interesting, you will never make a great success at it. If you cannot do this, change your occupation for another that pleases you better.

INCREASE IN SALARY.

Do not be continually asking for an increase in salary; and do not maintain a grouch because you think you are underpaid. If your employer is a man of the right sort, he will increase your compensation as fast as your services become more valuable. If, though, he is not that kind of man, but prone to take advantage of his employees (and, unfortunately, there is occasionally to be found an engineer of this type), leave him without a word. There is no use in arguing with a man of that stamp, for you cannot change his nature.

OVERTIME WORK.

It is sometimes necessary for an office force to labor overtime, in order to finish quickly some pressing piece of work; but it does not pay to make a practice of so doing when the working hours are properly adjusted to the average man's physical and mental capacity. It is better for the employer to pay the rank and file of his assistants for such overtime, but not those of high grade, as they can better be compensated at the end of the year, or by giving them time off for travel, study, or extra recreation. These men of high grade should be allowed two weeks' vacation per annum at full salary, but not the time-servers; for the latters' aim is to give no more than a mere *quid pro quo,* hence they are not entitled to any vacation on pay.

I have found that, for another reason, it is bad practice to permit of much overtime work, viz., that some of the men are prone to dawdle along during the regular hours and delay the completion of the job, in order that they may increase their earnings.

On the other hand, an ambitious young engineer should voluntarily work overtime, not only to expedite progress but also to obtain personal experience and to summarize, digest, and record his daily acquisition of knowledge. In some way or other, a conscientious em-

ployer will ensure that ultimately such a young man will receive compensation (not necessarily directly pecuniary) for his extra effort.

In my career as an employee I put in many long hours of overtime work; and for so doing I never received so much as an extra dollar. It is far more dignified and self-satisfying to serve as an engineer and not as a mere hireling.

READING AND STUDY.

Every young engineer who has the ambition to rise in the world should lay out and follow a course of reading and study. If he does not, he will soon drift into mediocrity. On the average, one should spend two hours per day in thus increasing his knowledge. This course of reading and study should be laid out by the advice of older engineers.

Whenever you can obtain them, read engineering reports on important projects, so as to learn how later to prepare such papers for your clients. Often the most valuable of such documents are never printed, for the reason that they contain information which the principals desire to keep private. These can often be borrowed under pledge of secrecy; and their perusal will prove of the utmost benefit.

ACQUAINTANCE.

Make a practice of becoming acquainted with as many engineers of prominence as you can; and, whenever you are introduced to one of them, endeavor to impress favorably upon him your personality. Acquaintance and friendship in engineering, as in all other walks of life, count for a great deal in one's worldly advancement. Moreover, such acquaintance will afford real pleasure as well as profit.

AIDING IN RESEARCH.

If you find that some of the engineers you meet are engaged on important research, offer your services gratis to help in their experiments and computations; and do your best really to aid them therein. The experience thus gained will be invaluable; and, besides, you may receive some public credit for your assistance on the work.

JOINING SOCIETIES.

Make a point of joining two or three technical societies, both national and local, and take part in their functions. Enter into their discussions of memoirs, and eventually write some of these yourself. Through such societies you will make friends, and at the same time improve your standing in the profession.

SETTING A GOAL FOR ATTAINMENT.

After a few years of practical experience, every ambitious young engineer should set for himself an ultimate goal to reach; and he should not be afraid of placing it too high, because, within the limits

of reason, there is no height to which an engineer who is gifted with ability, energy, perseverance, and *savior faire* cannot attain.

Even if one fail finally to climb the professional tree quite as high as he desired, the struggle to get there will have been advantageous; and it certainly will have carried him much further along than he would have gone without having a definite object constantly in view.

CONTINUED STUDY OF MOTHER TONGUE.

In my previous lecture I urged that students at college study thoroughly their mother tongue throughout the entire course of instruction; and now I advise that this study be carried along after graduation by means of a leisurely course of reading and by trying constantly to improve one's diction when writing books, memoirs, specifications, contracts, reports, etc., and even when dictating correspondence. Let me repeat that a thorough command of his own language is the most effective weapon an engineer can possess in his struggle for professional advancement.

By dabbling a bit in politics an engineer can become adept in public speaking. It will teach him to overcome stage-fright, if he be subject to that uncomfortable affliction, and will enable him quickly to collect his ideas, draw conclusions, and state his case.

BUSINESS.

The study of the business features of engineering practice should be continued after graduation. There are books on the subject to be read; but the main thing is to develop business methods of one's own that are specially suited to the work one has to do.

Considerable study should be given to the preparation of specifications and contracts. There is a little book of mine on the subject published by McGraw, Hill, & Company of New York City, which should be of great assistance to those of you who have a fair command of the English language. You will not find it difficult to draft contracts, because the best method thereof is fully expounded and exemplified in that work; but the preparation of specifications is quite another matter, for to do it properly requires actual experience in design and construction.

SYSTEMIZATION.

What I said concerning systemization of work at college applies with even greater force in actual engineering work. Everything connected with what you do should be systematized, so that there shall never be any loss of efficiency from failure to find anything needed or from not having everything arranged properly in advance of each step that is to be taken on the work. One should acquire such a habit of systemization that its practice becomes second nature.

In making computations, estimates, reports, and writings of all

kinds, cultivate a habit of neatness; and force your assistants to do the same.

BOOK-KEEPING.

A knowledge of elementary book-keeping is often of much benefit to an engineer, because he will sometimes be called upon to investigate the status of some established business for the purpose of valuation; and to do so he must be able to understand the books of the owner, in order to determine proper values for the property and the business.

OFFICE PRACTICE.

An office engineer should read books dealing with good systems of office practice; and eventually he should develop a system to suit his own special needs.

A thorough one for a bridge engineer is described in "Bridge Engineering." It is based upon an experience of fully thirty years, and was developed not by myself alone, but with the aid of several exceedingly capable assistants.

NOTES AND DIARY.

The keeping of notes in a pocketbook concerning things to be done will be found to be a great aid in the accomplishment of tasks. I carry in my pocket at all times such a note book; and many times per day—in fact, whenever I think of anything of importance to be done—I pull it out and jot down an item on the list. Also many times per day, especially when there occur a few minutes of leisure, I take out the book, so as to see whether there is listed anything that I can accomplish in those few minutes. As soon as an item has received attention a line is drawn through it; and when the list becomes badly scratched I begin a new one by carrying forward all the uncancelled items.

If you will adopt this system of note-keeping you will find that your capacity for accomplishment will be actually doubled.

Many people claim that relying upon notes in this way is destructive of one's memory; and there is some truth in the statement, nevertheless no great harm is done, because in engineering work it is generally an unsafe procedure to rely absolutely upon one's memory. I am unwilling to trust without notes as evidence the memory of any man—and especially my own.

The keeping of a diary is a nuisance; but, if I were a young man starting out in engineering, I certainly would keep one and record in it all happenings of importance. Remember, a diary is a book in which you write notes daily *not weekly* nor whenever you can find a convenient time. Generally, the notes therein should be entered at night after the day's work is done. The great advantage of a diary is that it informs you about where you were on any particular day and what you were then doing. It also often furnishes data for estimat-

ing upon how long it is going to take you or others to perform some impending task. Again, it is sometimes useful in lawsuits.

REVIEWING MATHEMATICS.

From time to time a graduate engineer should review his mathematics, so as not to lose the power to handle them, even if his work does not call for their employment. Unless one does this, he will soon forfeit his ability to manipulate mathematical formulæ, which would be very regrettable, notwithstanding the fact that most busy engineers in certain lines seldom, if ever, have occasion to employ any but the most simple kinds of mathematics.

Read occasionally your old college books, so as to keep their contents fresh in your memory. I assume that you will not be so foolish as either to sell or to give away any of them, thinking that you have finished with them forever and that in practice you will need others. While it is true that you must buy the new books as they come out, and either read them or make notes therefrom for future reference, you will find your college books to be exceedingly useful, because of your acquaintance with their contents and your ability to locate in them quickly any item which you remember to be there.

PERSONAL LIBRARY.

Every engineer should spend on the collection of a technical library all the money he can spare for that purpose. The books therefor should be selected with care, and notes should be made of what they contain of special value in the owner's line of work. It does not do to rely too much upon a public library or even upon that of one's technical society; because, when an engineer is in need of information, *he generally wants it now*, hence it should be at hand in his own library where he can find it without delay.

FOREIGN LANGUAGES.

Keep up your knowledge of any foreign language you may have studied, by reading, writing, and speaking therein. Never lose an opportunity to converse in his own language, if you can, with any foreigner whom you may meet. It is probable that he will prefer talking with you in yours; but, if so, do your best to force the conversation into his.

TRAVEL.

Take advantage of every opportunity to travel, especially in foreign countries; for there is nothing else that so broadens a man's character or so expands his vision as does seeing the world.

JUST DECISION.

Endeavor to train your mind to decide justly any question that may arise, discarding all thoughts of selfish interests in arriving at decisions.

TRUTH.

Permit me to repeat the admonition concerning truthfulness that I gave you in my first conference, viz.: "Adhere at all times strictly to the truth."

Remember that truthfulness in thought, word, and deed is a prime essential for success in the engineering profession. In making investigations attack your problems with an open mind and without the desire to find certain results. An engineer is essentially a searcher after truth; and he dare not wander from the straight and narrow path thereof. Sometimes it may occur that a client will ask his engineer, when preparing a report on a project, to prevaricate or make a false statement, deeming that so doing would facilitate the procuring of money for the enterprise. In such a case the only thing for the engineer to do is flatly to refuse. Any engineer who ever condescends to stultify himself in such a manner is sure to lose caste in the profession.

In business one's word should be as good as his bond; and a promise, when once given, should be strictly carried out—even to one's own financial detriment. The pursuing of this policy will necessitate one's being very careful not to make rash promises.

TECHNICAL INVESTIGATIONS.

Learn to make technical investigations and to record the results thereof by diagram. In preparing a series of computations, the diagrammed records thereof will generally indicate clearly whether any mistakes have been made in the figuring; and there is no method of expounding facts that is as clear and comprehensible as that of diagramming.

An engineer should study how to prepare "tracing diagrams." They are apparently quite complicated; but, after one learns how to use them, they are exceedingly convenient and satisfactory, for they record on a single sheet results derived from the consideration of several variables.

TECHNICAL WRITING.

Let me again urge you to undertake as soon as you properly can, the writing of technical memoirs for publication, and eventually, if practicable, that of a technical book or books. If your literary and scientific writings be really good, you will find that they will both give you high standing in the profession and increase your business or raise your salary.

The proper writing of technical books is an art; and it has been systemized, for in 1916 after completing my *magnum opus,* "Bridge Engineering," feeling that during its preparation (and previously on other books), I had learned much about the technique of

book writing, I prepared a memoir thereon and presented it for publication to the Society for the Promotion of Engineering Education. Its title is "Technical Book Writing"; and in it I submit a full exposition of how such works should be drafted. Before writing a technical book, it would pay an engineer to procure a copy of the memoir and read it several times, so as to be able easily to follow the directions therein outlined.

SAVING MONEY.

If possible, save some of your money and place it in sound investments, avoiding those that promise big returns; for almost invariably they involve the possibility of large loss. In mining engineering, though, it is not always wise to follow this advice too strictly; because, if an engineer truly believes that a mine which he is helping to develop has fine prospects of proving a great paying venture, it is often well for him to invest some of his savings in the stock of the promoting company.

While, in general, you should be careful of your money, when occasion calls for such procedure, spend it as a gentleman should. A reputation for niggardliness is simply damning—and deservedly so.

PUNCTUALITY.

Be punctual in keeping appointments. Remember that in arriving late you are wasting not only your own time but also that of others. A reputation for chronic unpunctuality is a serious draw-back to business success; moreover, it is most exasperating to all concerned. Arrive at your meetings either on the tick of the clock, or, preferably, a little before.

From what I have seen and heard in Spain, I fear that this advice is really needed here.

EARLY RISING.

Get up early in the morning and start your day's work as quickly as possible. The early hours of the day are far the best for the exercise of mental effort, because then the mind is clear and the body rested. I find that one hour in the morning is worth two at night, as far as accomplishment of work is concerned. Night should be the time for relaxation and rest. If one makes a practice of early rising, it will be necessary for him to retire at a reasonable hour; as it does not pay to burn the candle at both ends.

Experience has shown me that the necessary number of hours for sleep per day is seven for students, six for young engineers, and five for old ones. More than this is a waste of valuable time.

PHYSICAL EXERCISE.

No one should fail to take daily enough physical exercise to

keep him in good bodily condition. Remember the latin proverb "*mens sana in corpore sano,*" and heed its caution.

On the principle that a confirmed drunkard makes the best temperance lecturer, I ought to be well fitted to talk to you about the necessity for physical exercise; because for many years I have sadly neglected it, with the result that in my old age I have become too heavy for comfort or convenience. In this particular please "do as I say and not as I do."

CIVIC DUTIES.

Every individual should pay proper attention to his duties as a citizen of the country in which he resides. Engineers in America are great sinners in this particular; and the result is that our profession has very little to say regarding the government of the country. In the Administration, the Senate, and the House of Representatives at Washington engineers are conspicuous by their absence. This is a condition that should be corrected as soon as possible, for the benefit not only of our profession but also of that of the country, because who is there so competent in thought and action as an engineer?

In European countries, I believe, engineers take a more prominent part in politics than they do in the U. S. A.—for instance, in Italy there are twenty-three engineers who are members of parliament. What the conditions in Spain are I do not know; but I notice that the Alcalde of Barcelona is a distinguished engineer.

CONTROVERSY.

Invariably keep cool in controversy, be it either spoken or written. Remember that the disputant who loses his temper is almost always the one who comes out second best in the argument.

LITIGATION.

Avoid lawsuits. They are always costly and generally unsatisfactory in results—often to both parties of the litigation. Instead, cultivate the habit of compromise in business; and adjust your *modus vivendi* on the principle of "give and take." Most people at bottom are reasonable; and generally a disputed point can be adjusted by compromise after a calm discussion.

COURTESY.

Every engineer should aim to develop in himself to the utmost the habit of courtesy. It seems really unnecessary to make such a suggestion in Spain, where the entire nation is so eminently polite; but, in some of my travels, I have seen countries where the admonition would have been appropriate. A man never makes a mistake in treating others politely and kindly. Such action redounds to

his credit and makes him popular—and popularity is a great asset in the business world.

One should always pay full deference where deference is due: but this need not prevent a man from backing up fearlessly his own opinion.

AGGRESSIVENESS.

While a certain amount of aggressiveness in an engineer's make-up is necessary for a successful career, it must be remembered that one does not rise rapidly in the engineering profession (or, for that matter, in any other walk of life) by trying to push others down or to hold them back. Moreover, one seldom loses anything by doing a good turn for a brother engineer.

ECONOMY.

In the future, to be eminently successful in our profession, one must be not only a competent engineer but also a true economist. Up to the present it has usually sufficed to make one's constructions strong and durable—too often irrespective of cost; but today, when there is so much building to be done and so little money available, it behooves engineers to study the theory of true economy in their designs and apply its principles in all their works.

Distinction should be made between true economy and false economy. Many people think that the most economical thing is the one that costs least; but such is by no means the case. The definition of economy from the engineering standpoint, as given in two of my books, is "The science of obtaining a desired result with the ultimate minimum expenditure of effort, money, or material."

When determining, from the standpoint of economy, which one is the best of a number of proposed constructions or machines, there should be computed for each case the four following quantities and their sums:

A. The annual expense for operation.
B. The average annual cost of repairs.
C. The average annual cost of renewals.
D. The annual interest on the money invested.

That one for which the sum of these items is least is the most economic of all the proposed constructions or machines; but this statement is truly correct only when the costs of operation, repairs, and renewals are averaged for a long term of years; or else for a comparatively short period of time, when the conditions in respect to wear and deterioration at the end of the period are practically the same for all cases.

During the last four decades I have made and published many economic investigations in bridgework (a score or more); I was

selected by the President of the University of Kansas to prepare and deliver before his Engineering Faculty and Students a short series of lectures on "Engineering Economics"; I was for two years Chairman of the Committee on "The Study of Economics in Technical Schools" in the Society for the Promotion of Engineering Education; and I have written a large and very full treatise on "Economics of Bridgework." The reason why I am telling you these facts is to let you see that I have some claim to be deemed an economist, and so you will believe me when I assure you that the great engineers of the future will be those who apply throughout all their designs and constructions the established principles of economics.

CONCLUSION

By this time, young gentlemen, you must have had a plethora of advice; and, undoubtedly, many of you are glad that my long, rambling discourse has drawn to a close. However, I trust you will pardon me if I have caused you any weariness.

Accept my hearty wish that each of you may complete his course here satisfactorily and make his mark in the engineering world. If some of the words of this discourse prove of aid to any of you in either his scholastic or his professional career, my efforts in holding these conferences will have been amply compensated.

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